Progress on algorithms for induction hit finding II

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Overview

Some updates on:

- Effect of changing the number of data points summed up during each iteration
- R-dependence for different data sets
- Angular variation in S/N before and after absRS
- Performance for normal tracks
- Code availability

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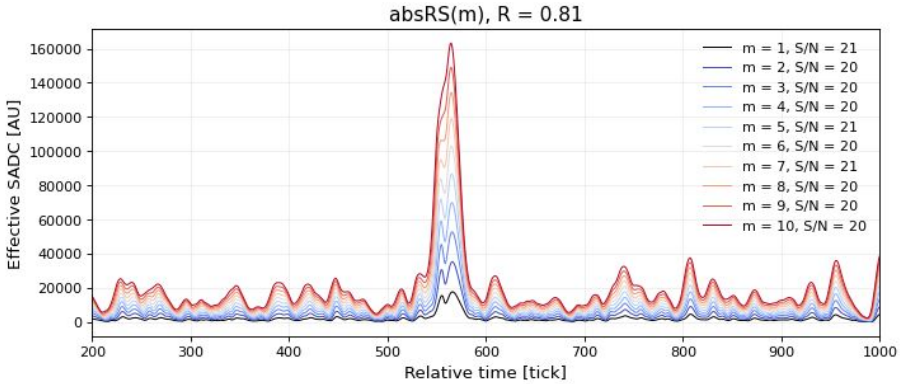
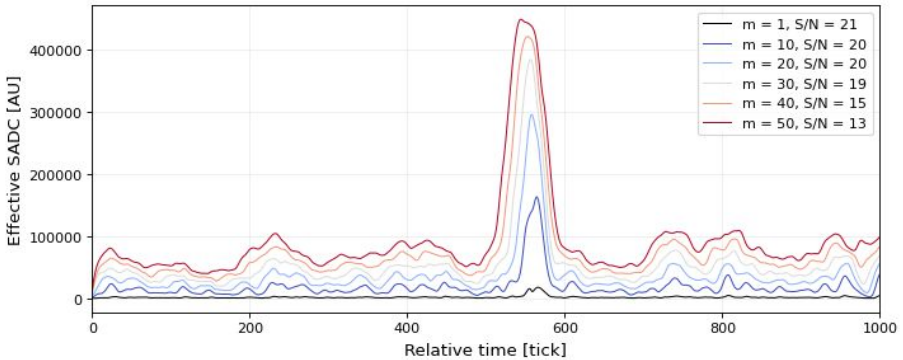
Changing number of sampled points (m)

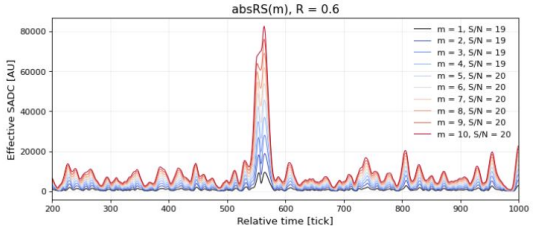
Effect of changing the number of data points added during the absRS summation:

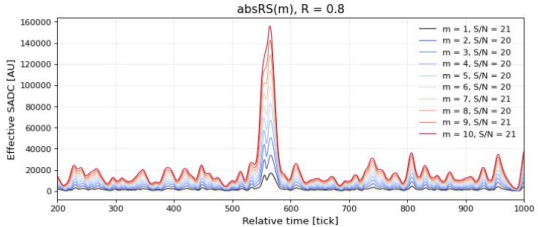
No significant improvement in S/N relative to the m=1 case, regardless of the assumed R-value.

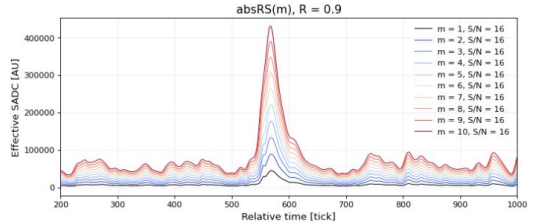
At m=10 double peak smoothed into a single one, but lack of improvement in the S/N & memory needs for storing that many data points outweigh that perk.











*Data from frames.bin in DAQ readout.

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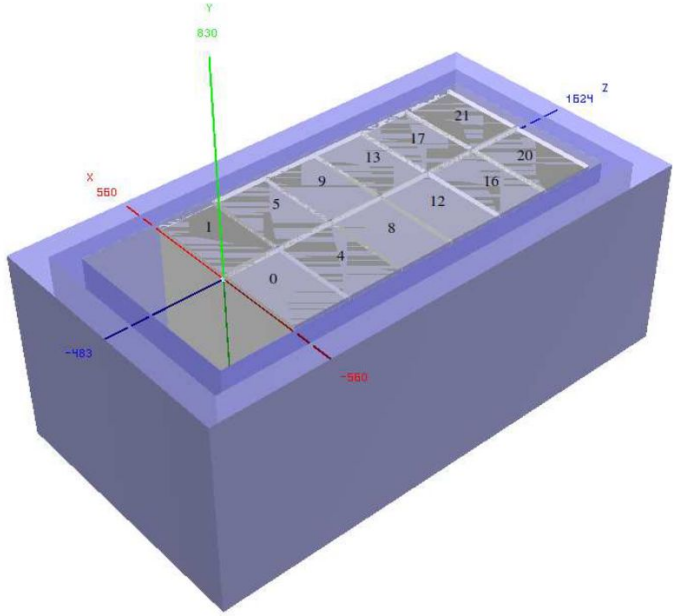
Data samples

Simulated data in LarSoft:

- 1000 single muon events
- E_k = 100 MeV → ~ 30 cm tracks.
- Flat angular distribution
- All tracks contained within TPC1
    - Reduces data volumes: only need to look at the 2560 channels in APA0.
- Only analysing channels with TPs for S/N studies.

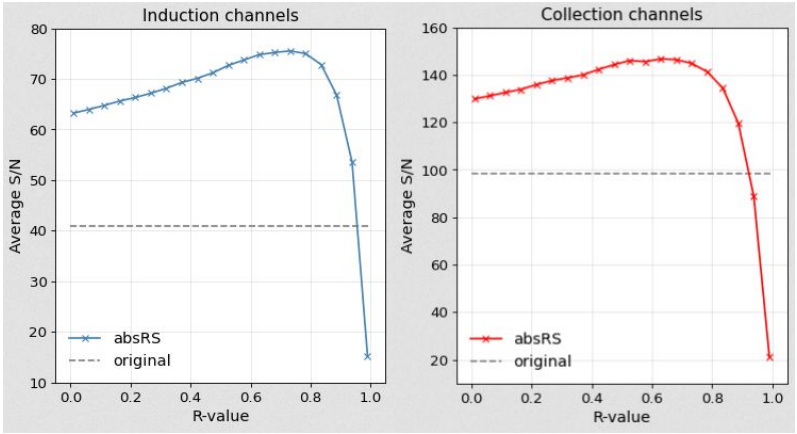


R-dependence of the new sample

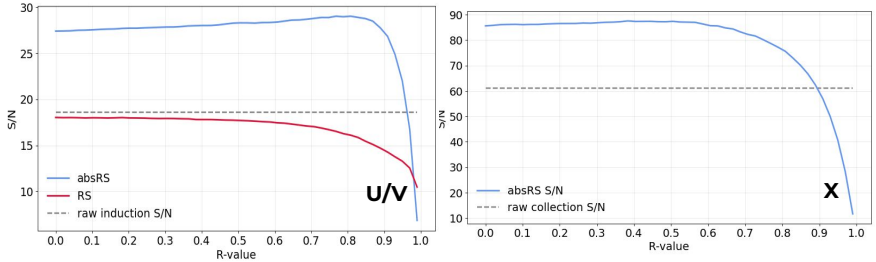
Overall relationship between the R-value and S/N holds for different data sets:

- Steady improvement in S/N, peaking at intermediate R-values, before rapidly deteriorating as R→ 1.
- The exact degree of improvement varies with the sample, but as long as 0.6 < R < 0.8 we can expect significantly higher S/N.

LarSoft



Readout



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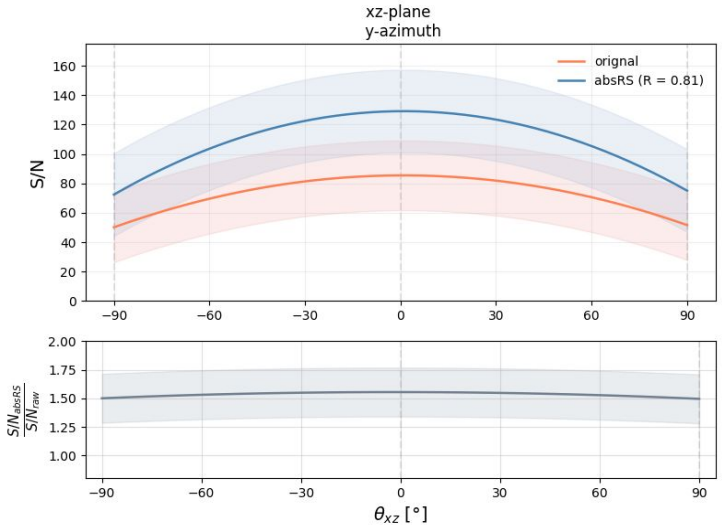
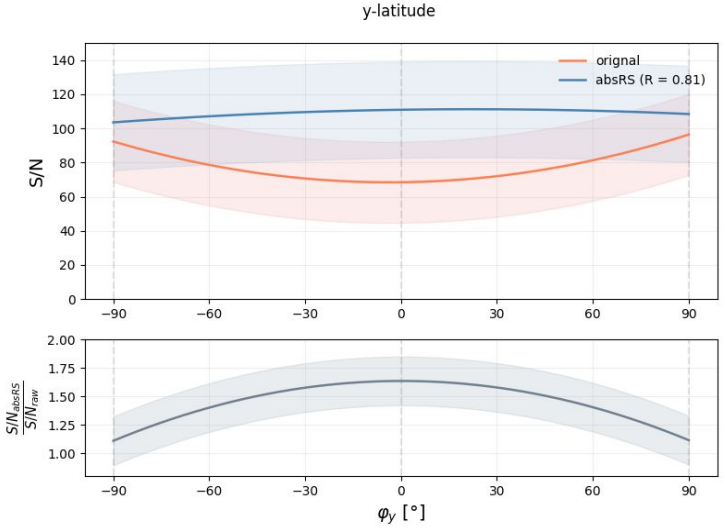
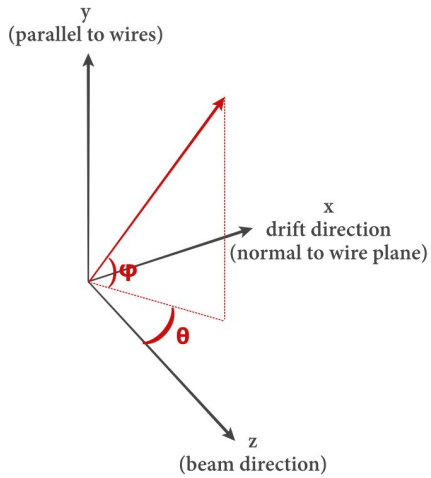
Angular dependence (collection)

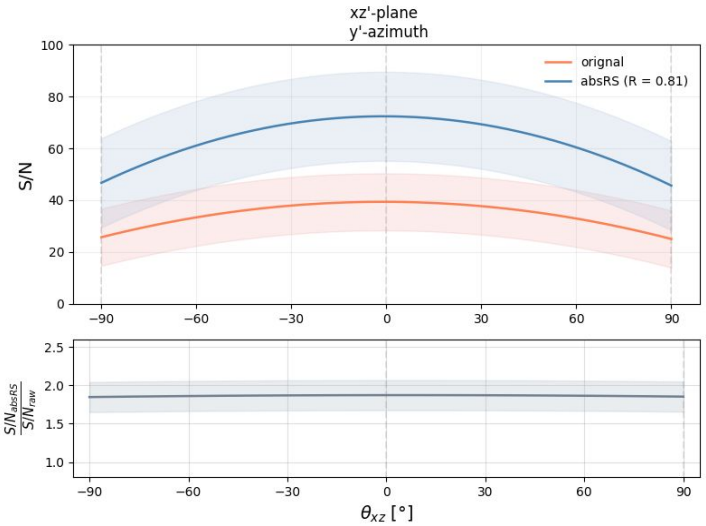


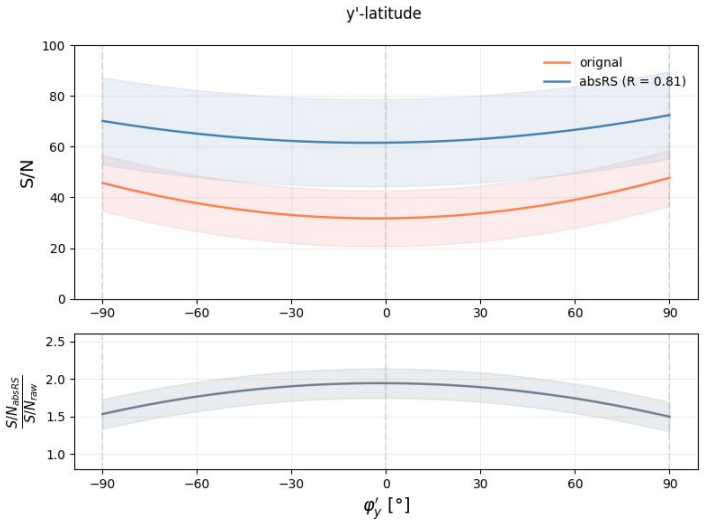


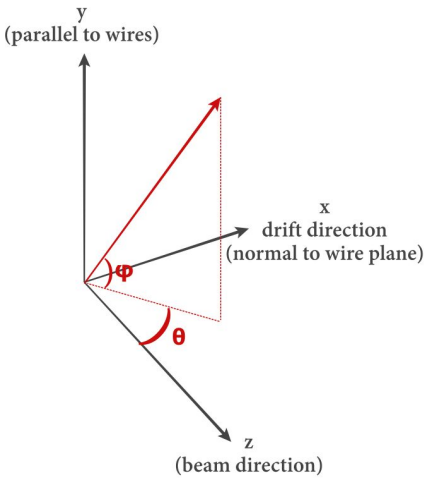


- Highest S/N when event is parallel to the APA plane (θ=0), and lowest when it's normal to it (along x-drift)
- Improvement in S/N relatively steady as the azimuth angle is varied.
- Surprisingly, the improvement is marginal for signals parallel to the wires (φ = +/- 90), when S is already high.

Angular dependence (induction)



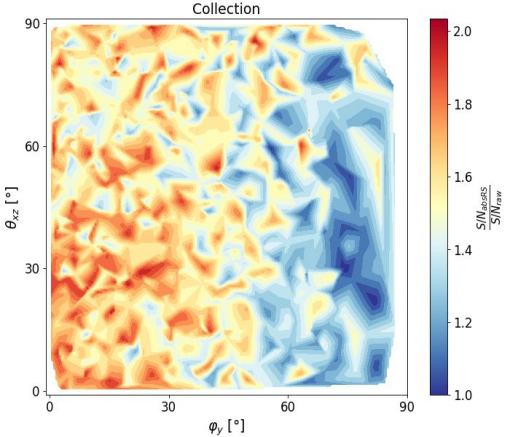


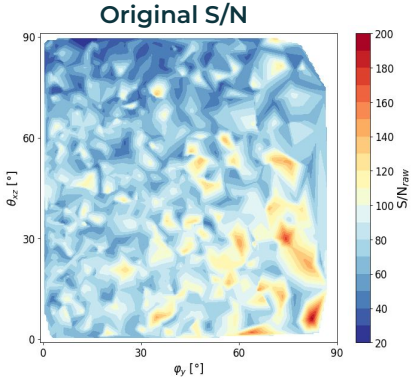


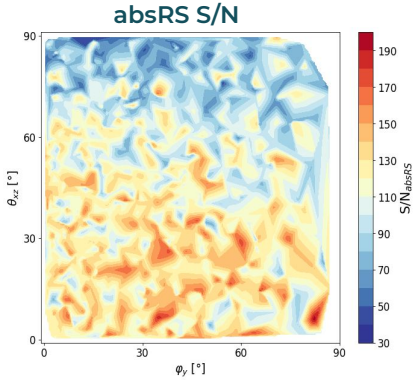
*θ_{yz}' = angle relative to induction wires
→ yz plane rotated by ±35.7° about the x-axis

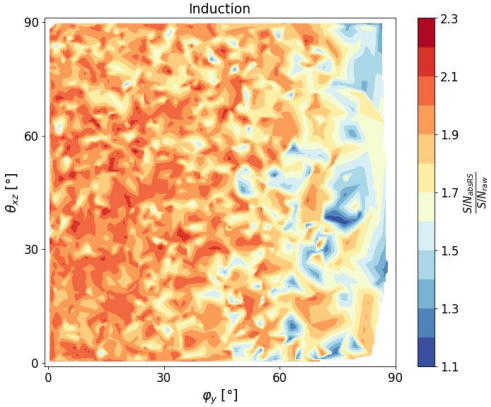
- Similar trends to collection wires; little dependence on azimuth angle, significant dependence on the y-latitude.
- Overall S/N improvement significantly higher than for collection wires, regardless of event orientation.

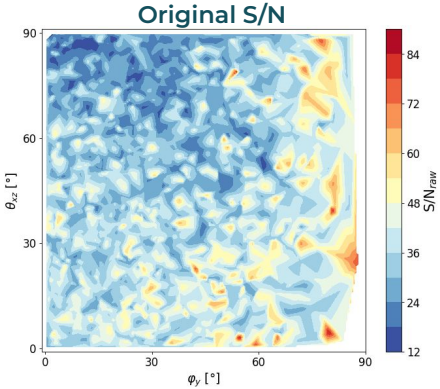
Overall angular dependence for both types of wires

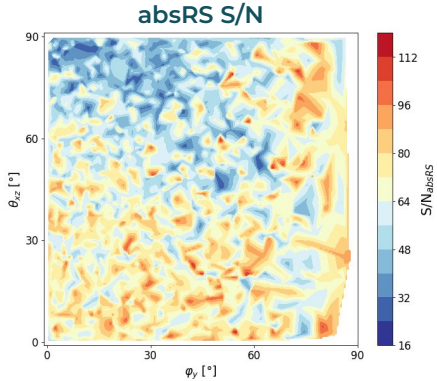












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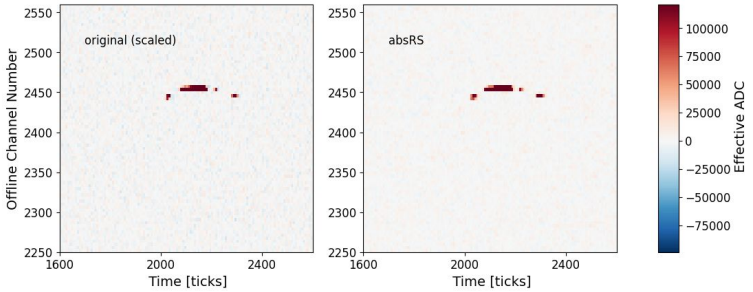
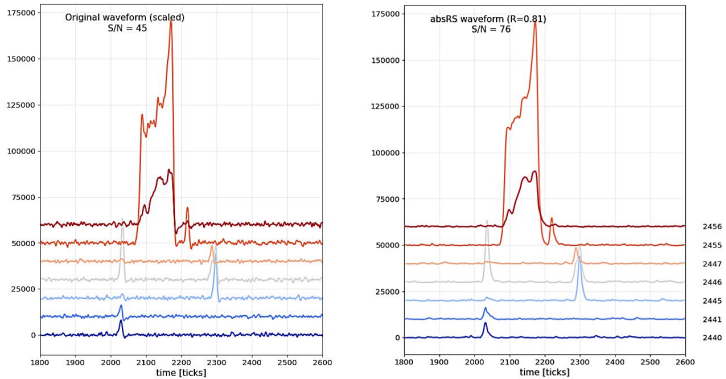
Normal tracks: collection signals

X-plane



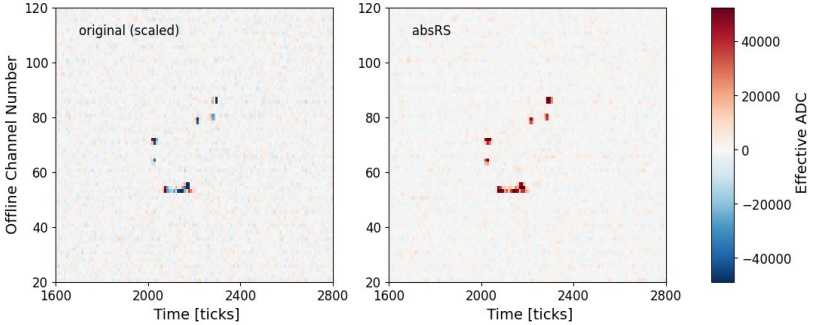


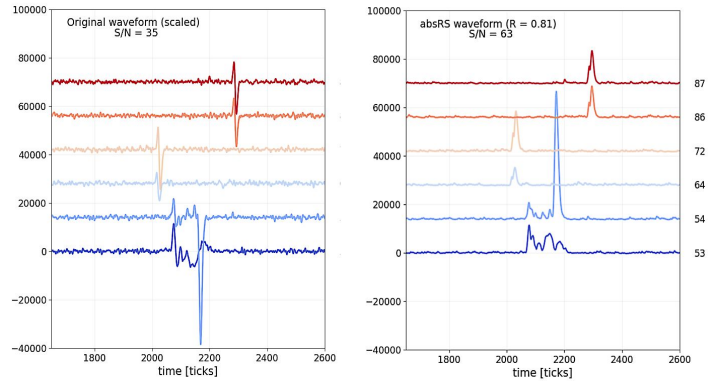
Looking at 100 MeV muon track normal to the wire plane

- Collection signals from normal tracks are characterised by a build-up of hits on single wires, with a few faint signals scattered about.
- At lower energies, when fewer hits are produced, this build up becomes increasingly difficult to detect, especially in the induction plane as the overlapping bipolar signals tend to cancel each other out.

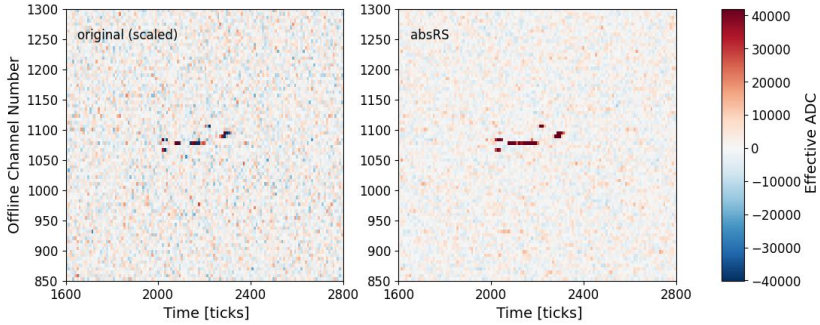
Normal tracks: induction signals

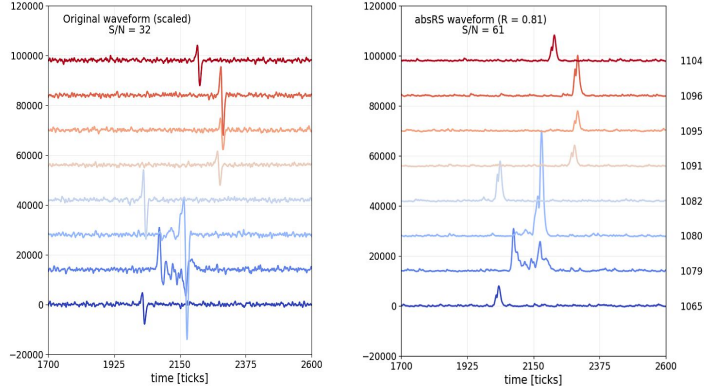
U-plane



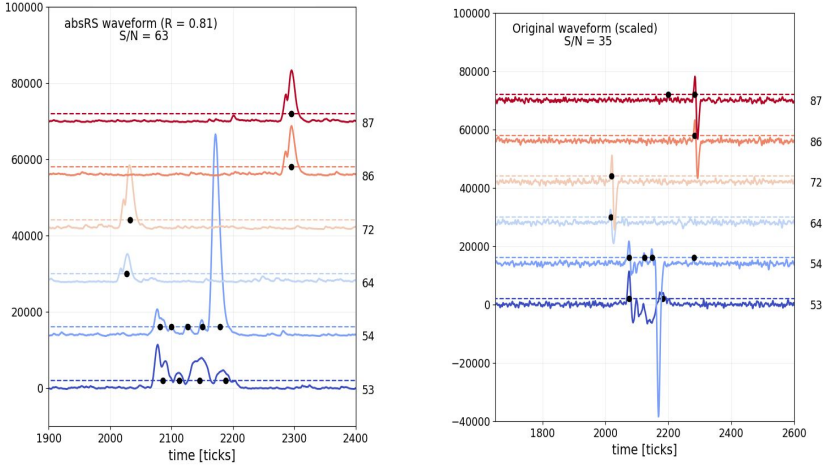


V-plane



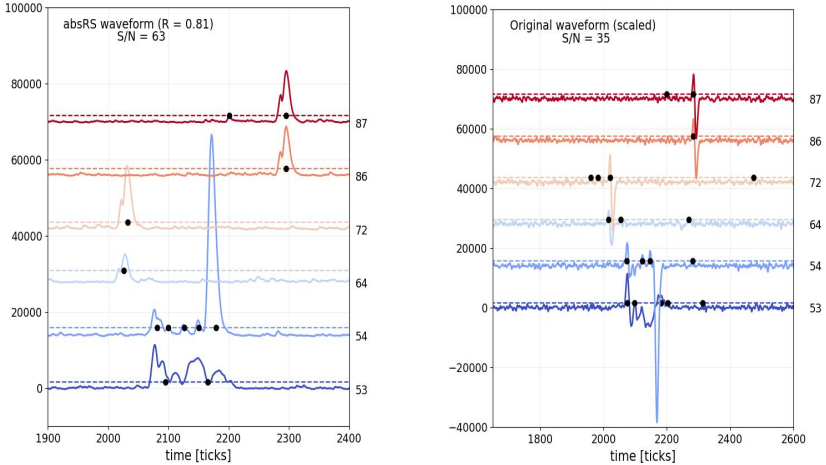


Induction hit finding for normal tracks



Hit finding with a fixed threshold (= 2000):

- The disappearing signals due to overlapping induction peaks are partially recovered by absRS.
- Improvements in S/N allow to set the hit threshold relatively low - can detect faint signals without picking up a lot noise.



Hit finding with a $5\sigma_{noise}$ threshold :

- Fewer false hits since large variations in the noise are smoothed out.
- Overlapping hits give long signals which increase the noise estimation on the wire → drives the threshold up so we end up with fewer, but longer hits (e.g wire 53)

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Code availability

Hit finder module for the absRS waveforms in LarSoft:

- New HF chain :
  - Pedsub
  - Filtering
  - absRS (+ waveform scaling)
  - Pedsub
  - HF
- Collection & induction wires treated in the same way.

Everything got pushed to the development branch:

- All files for the module in */dunetpc/dune/DAQSimAna/absRunningSumHitFinder*
- Analyser FHiCL “addnoise_AbsRunSum_snanas.fcl” in */dunetpc/dune/DAQSimAna/SNAnaClustering*

```
std::vector<short> absRunningSumTPFinderPass1::absRS(const std::vector<short>& filtered) {

  //--------------------------------------------
  //Absolute Running Sum Algorithm
  //--------------------------------------------
  //scale all values by 10 to make sure we don't exceed numeric limits for short
  std::vector<short> absRS_waveform(filtered.size(), 0); absRS_waveform[0] = filtered[0]/10;

  for (size_t i = 0; i < filtered.size(); ++i){
    absRS_waveform[i] = m_R*absRS_waveform[i-1] + std::abs(filtered[i])/10;
  }
  return absRS_waveform;
}
```